

PATENT ABSTRACTS OF JAPAN

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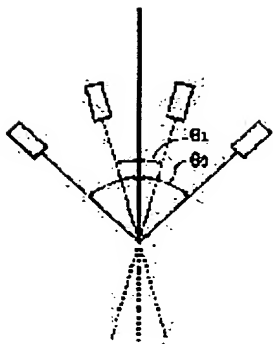
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(21)Application number : 08-068766 (71)Applicant : DAIDO STEEL CO LTD

(22)Date of filing : 25.03.1996 (72)Inventor : SUZUKI KIYOSHI

(54) METAL POWDER AND ITS PRODUCTION



(57)Abstract:

PROBLEM TO BE SOLVED: To produce powder having a small diameter and high in tap density by prescribing the angle of a spraying water flow to a falling molten metal flow.

SOLUTION: This powder is produced by the water spraying of molten metal, and the average grain size is regulated to $\leq 30\mu\text{m}$, and the relative tap density expressed by the ratio of true density to tap density lies in the range of 40 to 90%. In this production, it is important that the angle θ_1 of the water flow to be jetted lies in the range of 10 to 30 degrees. In this way, while the advantages of the water spraying method capable of producing small-sized powder are

utilized, the powder having an approximately spherical shape whose production has been impossible without depending on gas spraying can be obtd. As a result, the powder having a small diameter and high in tap density can be obtd., which is suitable as the material for a sintered product. Moreover, its compactability and the shape retainability of the compacted part are good as well.

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CLAIMS

[Claim(s)]

[Claim 1] Metal powder in the range whose relative tap density expressed with the ratio of tap density to the mean particle diameter of 30 micrometers or less and true density it is the powder manufactured by the water spray of a metal molten metal, and is 40 - 90%.

[Claim 2] Metal powder of claim 1 which a metal contains Mn:0.001-2.0% in formation of a steel alloy in addition to the alloy element of an and also [it is the need], and is the steel not more than Si:0.03%.

[Claim 3] a metal is ***** from Sendust, an Alnico alloy, PB permalloy, PC permalloy, and SUS316L -- the metal powder of claims 1 or 2 which are things.

[Claim 4] The manufacture approach of the metal powder characterized by making the angle of current injected in manufacture of the powder by the water spray of a metal molten metal to the molten metal style flowing down into the range of 10-30 degrees.

[Claim 5] The manufacture approach of the metal powder of claim 4 which contains Mn:0.001-2.0% in formation of a steel alloy as a metal in addition to the element of an and also [it is the need], and is carried out using the steel not more than Si:0.03%.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention offers the technique in which manufacture was made difficult and in which it is a minor diameter comparatively and what has a configuration close to a ball can moreover be obtained, by the conventional approach about manufacture of the metal powder by water atomization.

[0002]

[Description of the Prior Art] In manufacture of the metal powder by the molten metal atomizing process, when generally based on water atomization, it is easy for the grinding force of a molten metal style to build the powder of a minor diameter, since it is large compared with gas atomization. If it says with an average powder diameter, and it is water atomization, 30 micrometers or less will be easy and the thing of a minor diameter will amount to 60-70 micrometers in gas spraying to being made to about 10 micrometers. About the configuration of each powder, gas spraying builds the powder of a configuration with an irregular water spray to giving almost globular form powder.

[0003] The technique of following the procedure of remarkable MIM (metal injection mold)-sintering of progress in the field of powder metallurgy in recent years is advantageous when manufacturing the final product of a complicated configuration. Metal powder is wanted to fill up with the consistency with this most expensive possible injection-molded product. The qualities of injection-molding nature including the height of a filling factor are influenced by the configuration and dimension of metal powder. That is, it is a configuration near a ball and, moreover, the thing of a minor diameter is desirable. The same thing can say also about the technique by the procedure of compacting-sintering. In this case, as for extent in which it is required for that the firmness of powder-compacting mold goods should also be high, and metal powder is, it is desirable to have an irregular configuration.

[0004] It is a configuration near a ball, and the powder which the metal powder of a minor diameter was not obtained by the conventional water atomization, but manufactured by gas atomization is classified, and the approach considered first collects the things of a minor diameter. However, by this approach, since the yield is low, metal powder will become expensive naturally.

[0005] As an exception method, the powder of the minor diameter which manufactured by water atomization is processed with a jet mill, and there is the technique of removing a powdered irregular projection. When this also requires cost, in order that activation on the front face of powder may take place by processing and oxidation may progress, it is a fault that the oxygen content of water spray powder even with free [high] increases increasingly.

[0006]

[Problem(s) to be Solved by the Invention] The purpose of this invention conquers the above-mentioned problem in manufacture of the metal powder by the molten metal atomizing process, it is a minor diameter, and when a configuration moreover uses it for a ball at near and a metal injection mold, it is to offer suitable metal powder especially. Offering the manufacture approach of such metal powder is also included in the purpose of this invention.

[0007]

[Means for Solving the Problem] The metal powder of this invention is powder manufactured by the water spray of a metal molten metal, and is 30 micrometers or less of average radial balls, and the metal powder in the range whose relative tap density expressed with the ratio of tap density to true density is 40 - 90%.

[0008] The approach of this invention for manufacturing the above-mentioned metal powder is characterized by making the angle of current injected to the molten metal style flowing down into the range of 10-30 degrees in manufacture of the powder by the water spray of a metal molten metal.

[0009] Tilt angle θ of the spraying stream over a molten metal style which is seen to drawing 1 in manufacture of the metal powder by the conventional water atomization It was in the range of 35 degrees - 50 degrees about. When this generally considers the crushing energy effectiveness of the molten metal by the stream, The place where the include angle nearer to 90 degrees has higher effectiveness, at the include angle exceeding 50 degrees, component of a force upward at a colliding point arises, and a molten metal style is pressured upwards. There is an upper limit of 50 degrees from the problem that spraying is not performed appropriately, and energy efficiency is depended on 35 degrees having been adopted in general as a minimum from a viewpoint of

making it high, in the range which this problem does not produce.

[0010] When this invention person broke such common sense and water was sprayed at the small include angle of $\theta_1 = 10^\circ - 30^\circ$, it found out that powder with 1.5 or less overwhelming thing could do it, maintaining if the advantage of the water atomization that the powder of a minor diameter is obtained says a powdered configuration by the ratio of the thing near a ball, and a major-axis minor axis.

[0011] A fine molten metal drop arises by the water spray, as this device, while it has not received not much big deformation according to the difference of the spraying direction, it is cooled, and it is possible to solidify. If whenever [tilt-angle / of a spraying stream / large (it is near to 30 degrees)] is taken, the metal powder obtained will become a thing near the conventional water spray powder, and the description of ***** and this invention will be demonstrated by altitude small (it is near to 10 degrees). Implementation with a real unit is difficult for a tilt angle smaller than 10 degrees.

[0012] Since the energy efficiency of spraying water is naturally lower than a conventional method when based on this invention, it must be large capacity from what needs to use a lot of water and also twists the facility for the cooling and circulation on the conventional technique. However, the advantage that a minor diameter and spherical powder are obtained compensates this, and there is not much.

[0013]

[Embodiment of the Invention] Although it is applicable to the metal of the arbitration used carrying out disintegration by the molten metal atomizing process, this invention is useful when it applies to manufacture of the metal powder produced commercially especially with MIM shaping. If an example is given, there is a magnetic alloy like Sendust, an Alnico alloy, PB permalloy, and PC permalloy. Stainless steel like SUS316L is also leading as an object of application of this invention.

[0014] When applying this invention to steel, as for the steel, it is desirable that it is what contains 0.001 - 2.0% of Mn in formation of a steel alloy in addition to the alloy element of an and also [it is the need]. The reason is in the behavior of the oxide coat at the time of the drop of a molten metal congealing. Mn is made to exist like this invention, Mn oxide which produced especially the percentage by ***** and oxidation of Mn more highly generates the mineral of hypoviscosity, and the degree to which a surface oxide coat bars balling-up of molten metal becomes low.

[0015] As for S in the steel which applies this invention, it is desirable that it is 0.03% or less of low content. when the metal especially used as powder is a magnetic metal and is that of which low coercive force is required as elasticity magnetism material, it comes out so. If it says in the example of PC permalloy, the coercive force in the case of 0.06%

of S contents will attain to 4-5Oe, but if it becomes 0.02%, it will be 3Oe extent.

[0016]

[Example] Water spray equipment in ordinary use is converted, and it enabled it to change whenever [spray angle / of spraying water] to 10 degrees, 20 degrees, 30 degrees, and 50 degrees to a molten metal style. although the pressure of a spraying water nozzle is as fixed as 500kg/cm² -- supply -- amount of water is made to be set to 810l. / min of the time max, and 540l. / min of the time min whenever [tilt-angle], and the spraying water of an amount linearly changed according to the include angle was supplied at the time of whenever [middle tilt-angle]. [degrees / 10] [degrees / 50]

[0017] PC permalloy and SUS316L stainless steel with the following alloy presentation (% of the weight, remainder Fe) are dissolved. Alloy C Si Mn nickel Cr Mo P S Cu O N
PC . 002 .95 .01 78.16 - 1.04 .005 .005 . 02 .20 .002 316L .02 .53 .38 13.01 17.17 2.57 .015 .015 .02.23 Disintegration was carried out with the equipment of .010 above. About the powder obtained by whenever [each tilt-angle], it is JPMA. Tap density was measured according to the approach of setting to P08, and the result shown in drawing 2 was obtained.

[0018] Each microphotography (scale factor 1600) is shown in drawing 3 and drawing 4 among the powder of SUS316L about the thing of 50 degrees of things with a tilt angle [of a spraying stream] of 10 degrees.

[0019] When following this invention so that it may see in the graph of drawing 2 , the metal powder in which high tap density is conventionally shown compared with elegance is obtained. Probably the reason has the metal powder of this invention in their being a minor diameter and a spherical thing compared with the conventional water spray powder, and it will be clear from the comparison of the configuration of the metal powder shown in drawing 3 and drawing 4 .

[0020]

[Effect of the Invention] It became possible to manufacture the almost globular form powder it was presupposed that could not be manufactured on the other hand in manufacture of the metal powder by the molten metal atomizing process by this invention taking advantage of the advantage of the water atomization that manufacture of the powder of a minor diameter is possible if not based on gas spraying by water atomization. Consequently, metal powder with small mean particle diameter and high tap density can be offered now.

[0021] Such metal powder is suitable as an ingredient of the sintered product using the MIM method. Therefore, much more development of the MIM method can be aimed at by this invention. Moreover, since a powder-compacting moldability thru/or the

firmness of a powder-molding article are also good, the metal powder of this invention is useful also to manufacture of the product by press-forming-sintering in ordinary use.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The conceptual diagram having shown the powder manufacturing method of this invention as compared with the conventional method.

[Drawing 2] The graph which is data of the example of this invention and shows the relation of the tilt angle of a spraying stream and the tap density of SUS316L powder to a molten metal style.

[Drawing 3] The microphotography in which the configuration of the SUS316L powder manufactured according to this invention and a dimension are shown (scale factor 1600).

[Drawing 4] The microphotography in which the configuration of the SUS316L powder manufactured by the conventional water atomization and a dimension are shown (scale factor 1600).

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(71) 出願人 000003713

大同特殊鋼株式会社

愛知県名古屋市中区錦一丁目11番18号

(72) 発明者 鈴木 喜代志

愛知県東海市加木屋町泡池11-572

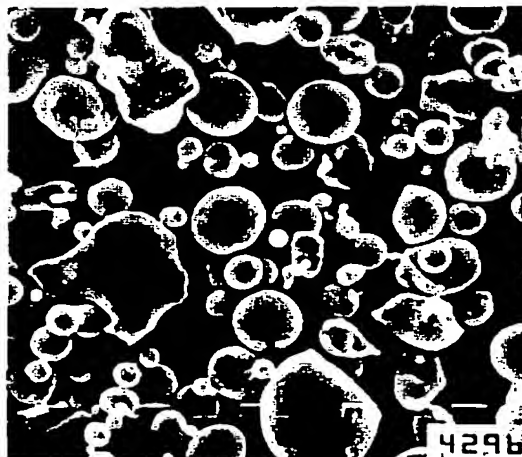
(74) 代理人 弁理士 須賀 総夫

(54) 【発明の名称】 金属粉末およびその製造方法

(57) 【要約】

【課題】 溶湯噴霧法による金属粉末の製造において、改良された水噴霧法を実施して、水噴霧粉の特徴である小径の粉末であって、しかもガス噴霧法による場合に近いほぼ球形の粉末を得ること。

【解決手段】 溶湯流に対して噴射する噴霧水流の、溶湯流の方向との傾斜角度を $10^{\circ} \sim 30^{\circ}$ の小さい角度にえらぶ。



【0004】球に近い形状であって小径の金属粉末は、従来の水噴霧法では得られず、ガス噴霧法により製造した粉末を分級して小径のものを集めるのが、まず考えら

【0011】この機構としては、水噴霧により細かい溶湯液滴が生じ、それが噴霧方向の差によりあまり大きな変形を受けないまま冷却されて、凝固するということが考えられる。噴霧水流の傾斜角度を大きく（30°に近く）とれば、得られる金属粉末は従来の水噴霧粉に近いものとなり、小さく（10°に近く）えらべば、本発明の特徴が高度に発揮される。10°より小さい傾斜角は、実装置で実現困難である。

【0012】本発明によるときは、噴霧水のエネルギー効率が当然に従来法より低いから、多量の水を使用する必要があり、その冷却および循環のための設備も従来技術によるものより大容量でなければならない。しかし、小径かつ球状の粉末が得られるという利点は、これを補って余りある。

【0013】

【発明の実施態様】本発明は、溶湯噴霧法により粉末化して使用する任意の金属に対して適用可能であるが、とくにMIM成形により製品化する金属粉末の製造に適用したとき、有用である。実例を挙げれば、センダスト、アルニコ、PBパーマロイ、PCパーマロイのような磁性合金がある。SUS316Lのようなステンレス鋼もまた、本発明の適用の対象として有力である。

【0014】鋼に対して本発明を適用する場合、その鋼は、0.001~2.0%のMnを、鋼合金の形成に必要な他の合金元素に加えて含有するものであることが望ましい。その理由は、溶湯の液滴が凝固する際の酸化物被膜の挙動にある。本発明のようにMnを存在させ、とくにそのパーセンテージを高めにえらぶと、Mnの酸化により生じたMn酸化物が低粘度の鉱物を生成し*

合金	C	Si	Mn	Ni	Cr	Mo	P	S	Cu	O	N
PC	.002	.95	.01	78.16	—	1.04	.005	.005	.02	.20	.002
316L	.02	.53	.38	13.01	17.17	2.57	.015	.015	.02	.23	.010

上記の装置で粉末化した。各傾斜角度で得られた粉末について、J PMA P08に定める方法に従ってタップ密度を測定し、図2に示す結果を得た。

【0018】SUS316Lの粉末のうち、噴霧水流の傾斜角10°のもの50°のものについて、それぞれの顕微鏡写真（倍率1600）を図3および図4に示す。

【0019】図2のグラフにみるように、本発明に従うときは従来品にくらべて高いタップ密度を示す金属粉末が得られる。その理由は、本発明の金属粉末が従来の水噴霧粉にくらべ小径かつ球状のものであることにあり、それは図3および図4に示した金属粉末の形状の比較から明らかであろう。

【0020】

【発明の効果】本発明により、溶湯噴霧法による金属粉末の製造において、小径の粉末の製造が可能であるという水噴霧法の利点を生かし、一方、ガス噴霧によらなければ製造できないとされていたほぼ球形の粉末の製造を水噴霧法で行なうことが可能になった。その結果、平

*て、表面の酸化物被膜が熔融金属の球状化を妨げる度合が低くなる。

【0015】本発明を適用する鋼中のSは、0.03%以下の低い含有量であることが望ましい。とくに、粉末にする金属が磁性金属で、軟質磁性材として低保磁力を要求されるものである場合にそうである。PCパーマロイの例でいえば、S含有量0.06%の場合の保磁力は4~50eに及ぶが、0.02%ならば30e程度である。

【0016】

【実施例】常用の水噴霧装置を改造して、噴霧水の噴射角度を溶湯流に対して10°、20°、30°および50°に変化できるようにした。噴霧水ノズルの圧力は500kg/cm²と一定であるが、供給水量を、傾斜角度10°のとき最大の810リットル/min、50°のとき最小の540リットル/minとなるようにし、中間の傾斜角度のときはその角度に応じて直線的に変化させた量の噴霧水を供給した。

【0017】下記の合金組成（重量%、残部Fe）をもつPCパーマロイおよびSUS316Lステンレス鋼を溶解し、

均粒径が小さくてタップ密度の高い金属粉末が提供できるようになった。

【0021】このような金属粉末はMIM法を利用した焼結製品の材料として好適である。従って本発明により、MIM法のいっそうの発展がはかれる。また本発明の金属粉末は、圧粉成形性ないし粉末成形品の保形性も良好であるから、常用のプレス成形—焼結による製品の製造にも有用である。

【図面の簡単な説明】

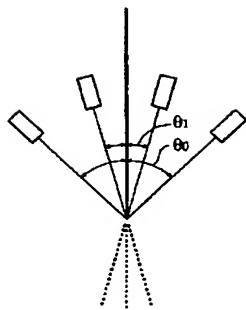
【図1】本発明の粉末製造法を、従来法と比較して示した概念図。

【図2】本発明の実施例のデータであって、溶湯流に対する噴霧水流の傾斜角とSUS316L粉末のタップ密度との関係を示すグラフ。

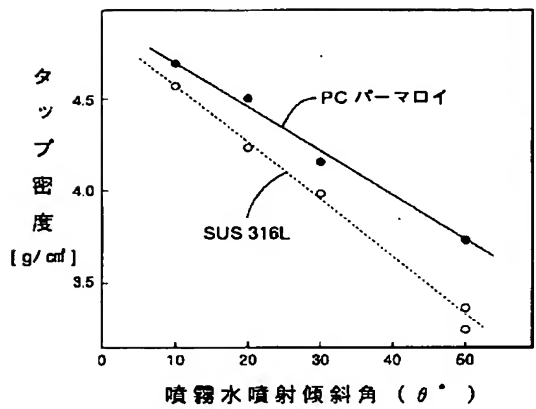
【図3】本発明に従って製造したSUS316L粉末の形状、寸法を示す顕微鏡写真（倍率1600）。

【図4】従来の水噴霧法で製造したSUS316L粉末の形状、寸法を示す顕微鏡写真（倍率1600）。

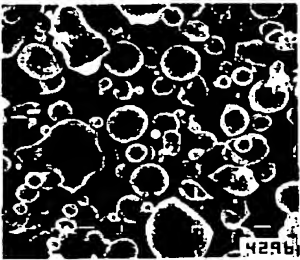
【図 1】



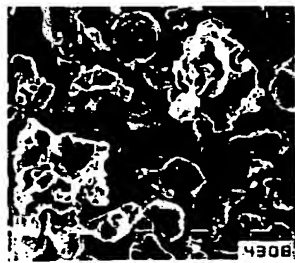
【図 2】



【図 3】



【図 4】



【手続補正書】

【提出日】平成 8 年 4 月 5 日

【手続補正 1】

【補正対象書類名】明細書

【補正対象項目名】請求項 2

【補正方法】変更

【補正内容】

【請求項 2】 金属が、Mn : 0.001 ~ 2.0 % を、鋼合金の形成に必要な他の合金元素に加えて含有し、S : 0.03 % 以下の鋼である請求項 1 の金属粉末。

【手続補正 2】

【補正対象書類名】明細書

【補正対象項目名】請求項 5

【補正方法】変更

【補正内容】

【請求項 5】 金属として、Mn : 0.001 ~ 2.0 % を、鋼合金の形成に必要な他の元素に加えて含有し、S : 0.03 % 以下の鋼を使用して実施する請求項 4 の金属粉末の製造方法。